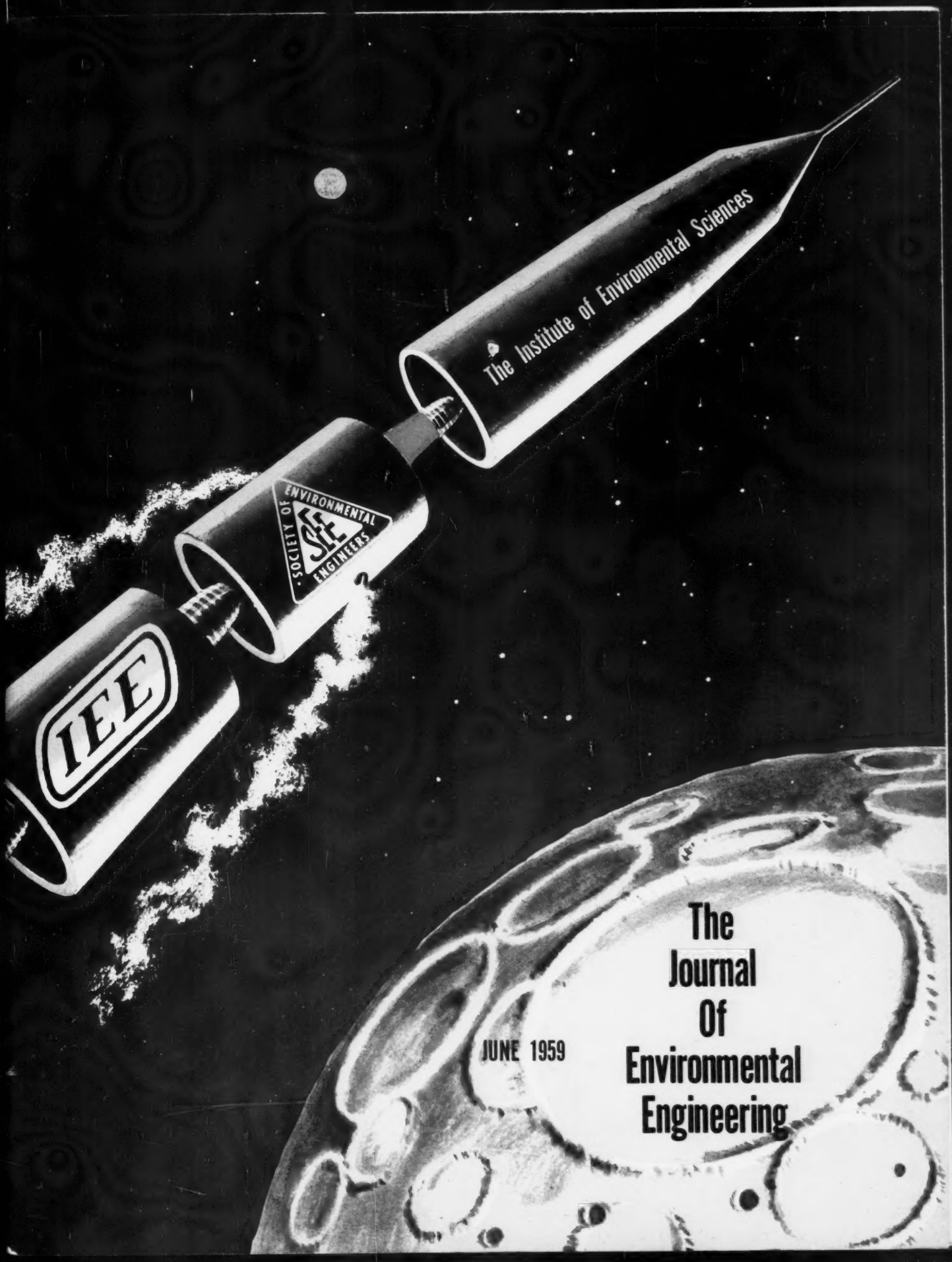

The Journal Of Environmental Engineering

JUNE 1959

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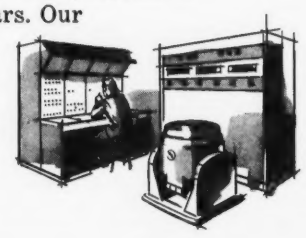

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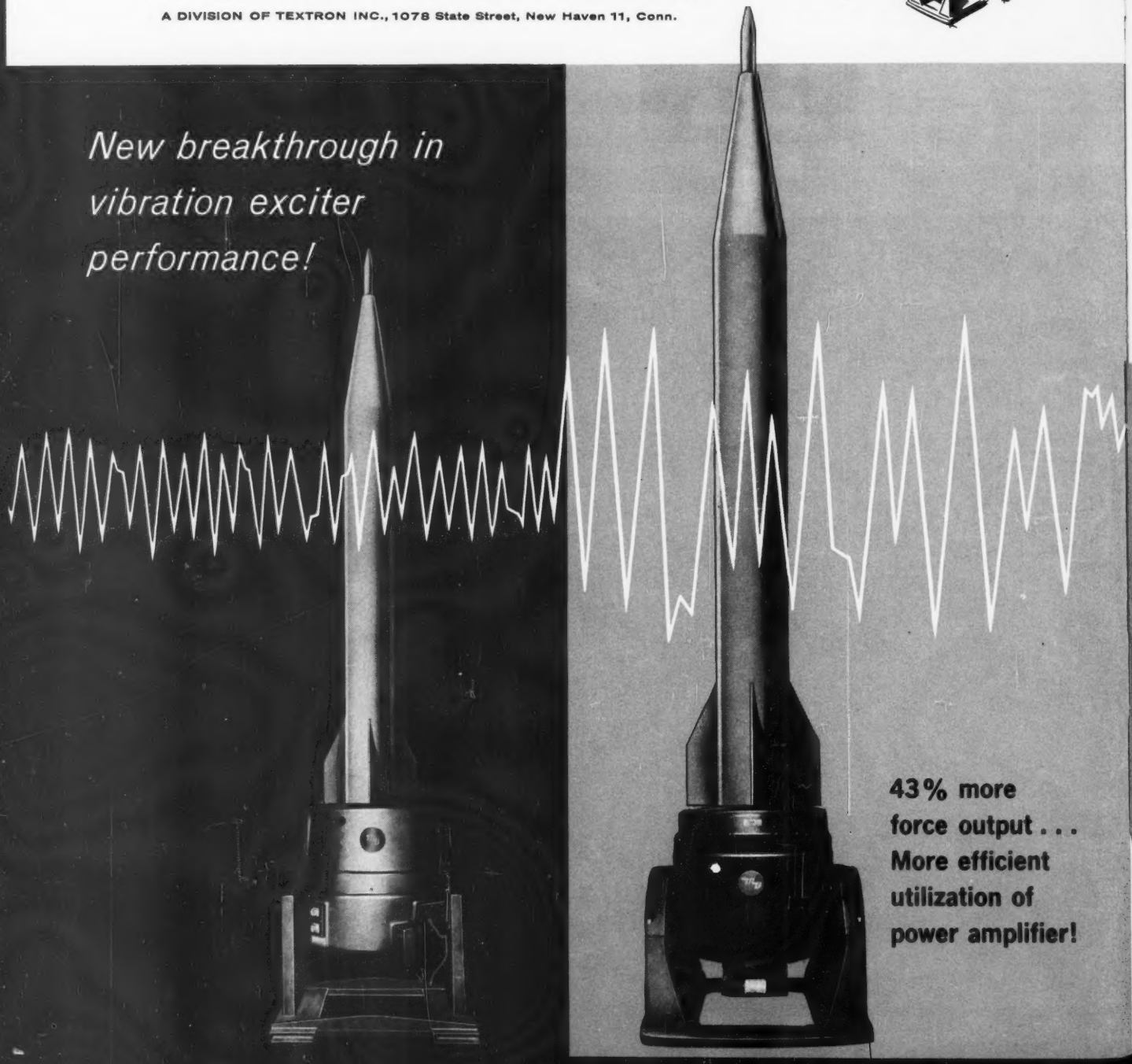
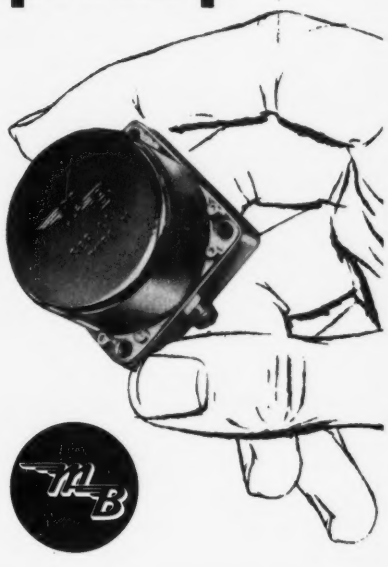


43% more force output... More efficient utilization of power amplifier!

Advanced design in a vibration pickup



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The Journal Of Environmental Engineering

VOLUME 2 NUMBER 3

Published for active Environmental Engineers and the executives throughout industry who are concerned with the advancement of Environmental Engineering by the Institute of Environmental Sciences.

Charles W. Danielson, Managing Editor JUNE 1959

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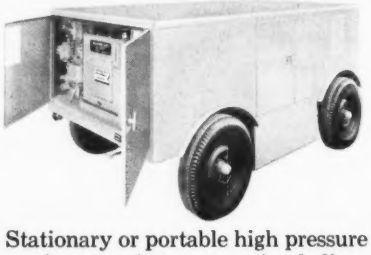

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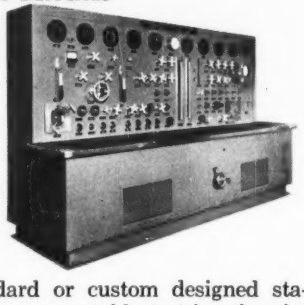

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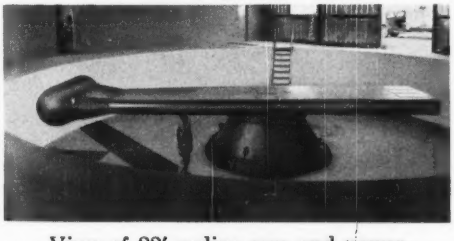
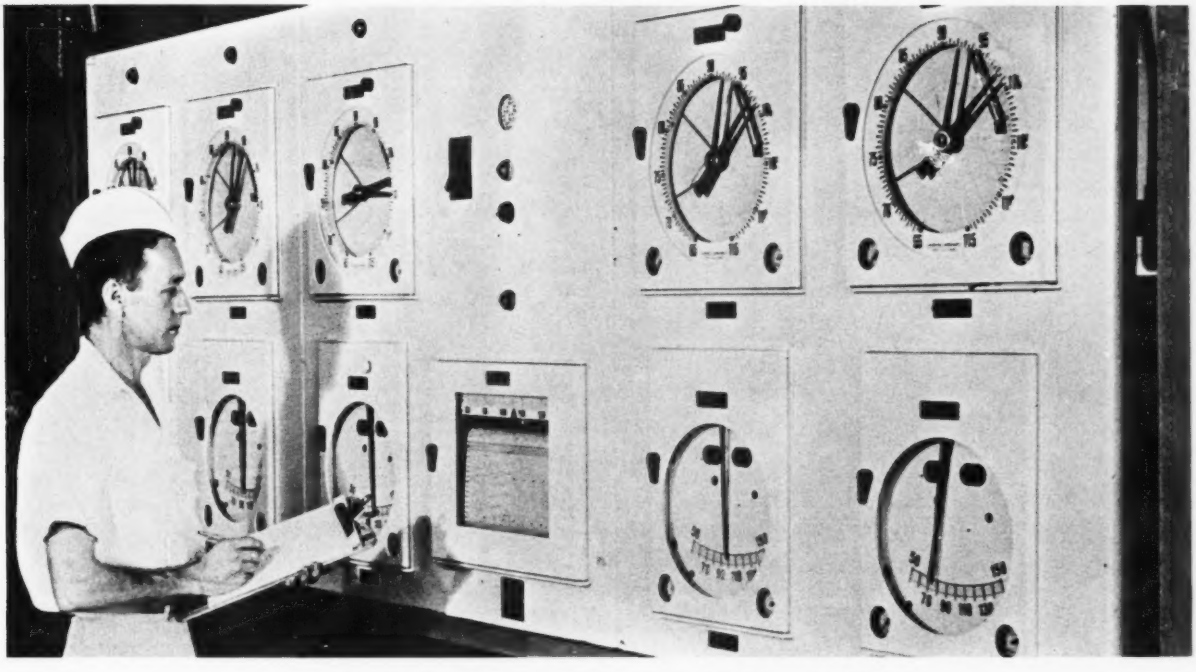


View of 22′ radius arm and powerhead installed in test pit. This large Series 20 unit is designed for testing 4,000 lb. specimen at 100 G-rating.



Pneumatic instruments and systems can do their best work only when they can draw on an unrestricted supply of clean, dry air.

A steady supply of clean, dry air keeps your pneumatic instruments going. Here are a few suggestions on how to prevent them from strangling on moisture and contaminants

Keep Them Breathing

Reprinted by permission of Minneapolis - Honeywell Regulator Co.

Although no one would expect the pilot of a jet fighter plane to do a good job with slugs of water, chunks of grit, or spurts of oil coming through his oxygen mask, it's surprising the lack of thought some people give to their pneumatic instruments and control systems.

Like the pilot, these instruments and systems can do their best work *only* when they can draw a continuous supply of *clean, dry air.* Since most industrial plants have compressed air supplies, this seems, at first glance to present no problem. There is a problem, though, and it's posed by the three words, *continuous, clean* and *dry.*

It's a sad but true fact that most plant air-supply systems contain so much oil and water that it's almost impossible to get the air clean enough for use in pneumatic control systems.

The first thing we should do then is install a separate compressor to supply instrument air. However, even this will not automatically insure a continuous supply of clean, dry air.

There will still be the problem of moisture either from the condensation of water vapor normally present in the air, or, occasionally, from water droplets sucked into the compressor on rainy or foggy days.

If air could be compressed *without change in temperature,* its ability to hold water vapor would decrease, and moisture would con-

dense in the compressor. However, the air is always heated during compression, so no condensation takes place in the compressor.

When it leaves the compressor, however, the compressed air cools to the temperature of the surrounding air, either in the capacity tank or the transmission lines, and excess moisture will condense into liquid. The cooler the air becomes, the more condensation you get.

It isn't too difficult to picture the possible effects of even small amounts of water wandering around in your instrument air-supply lines. Because pneumatic instruments and control units are designed for precision service, they must contain extremely small nozzles, orifices and restrictions. A precisely machined orifice, designed to pass air at a certain rate, will not pass a slug of water at the same rate. The result—greatly decreased instrument response.

If some of the instruments or transmission lines are located outside, freezing can occur during the winter months, and instruments or even entire control systems can be knocked out of service.

Moisture alone is not the only enemy of pneumatic instruments. Oil may be mixed with the compressed air by old, worn compressors, particularly when they are overloaded. Sometimes the compressors run too hot and carbonize the oil, causing bits of carbon to get into the air supply. Rust, scale and dirt are often formed by corrosion of the piping, especially if there's any condensate present. These corroded particles may be jarred loose by vibration and water hammer, and carried along in the instrument air supply. You can avoid most of this scale trouble by using copper, aluminum or plastic air supply lines and brass valves.

AMBIENT CONDITIONS (AT ATMOSPHERIC PRESSURE) RELATIVE HUMIDITY AT TEMPERATURE INDICATED													Dew Point (°F)	Saturation Vapor Pressure P_s	Moisture Content H_s
−20° F	−10° F	0° F	10° F	20° F	30° F	40° F	50° F	60° F	70° F	80° F	90° F	100° F			
100	57	33.5	20										−20	.0082	.00027
	100	58.5	35	21	13.4								−10	.013	.0006
		100	60	37	23	15							0	.021	.00080
			100	61	38	26	17.3	12					10	.034	.0013
				100	62	41.5	28.5	20	14				20	.054	.0021
					100	67	45.5	32	22.5	16	11.6		30	.082	.0034
						100	69	47.5	33.5	24	17.4	12.7	40	.12	.0052
							100	70	49	35	25.5	19	50	.18	.0076
								100	70	50	37	27.3	60	.26	.011
									100	72	52	38.5	70	.36	.016
										100	72.5	53	80	.50	.022
											100	74	90	.70	.031

The presence of rust, scale or dirt can add up to instrument and control stoppages and the need for frequent shutdowns to clean restrictions, nozzles and supply lines.

What to Do About It

Most, but not all of the solids present in the outside air are stopped by the intake filter on the air compressor. In order to stop whatever particles get by the filter, and any carbonized oil from the compressor, it's a good idea to install an air filter in the main air supply line just downstream from the capacity tank.

Next, we tackle the problem of keeping rust and scale from reaching the instruments. This, we can do by installing in the air supply to each instrument the combination air filter and pressure regulator shown in one of the illustrations.

This unit has a ribbon-type filter cartridge that can remove foreign particles with dimensions as small as 40 microns. Since the dripwell is intended to remove only the final traces of moisture in the air, it has a fairly small capacity and must be blown down frequently through the stopcock in the bottom unless the air supply to the unit is already relatively dry.

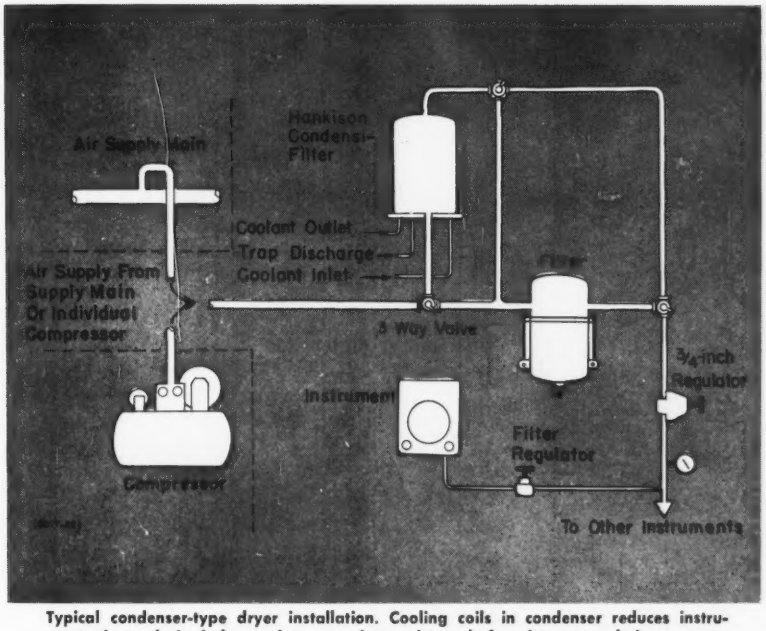
High-velocity air from the supply line is driven downward into the filter base where oil, water and heavier particles are deposited. Having been mechanically cleaned, the air then rises at low velocity through the filtering material which removes the lighter airborne particles.

In most cases, this same filter and dripwell unit will remove most of the oil present in the air. However, in plants where the air supply contains an excessively large amount of oil, it's a good idea to install a commercially available air filter.

Occasionally, a compressor will be so badly worn that even the two methods just described will be unable to remove all the oil. The answer here is to replace or rebuild the compressor. If this isn't economically feasible, the air can be bubbled through a solvent or passed through special filters of standard commercial design.

Getting the Moisture Out

Before going into the various methods of moisture removal, let's make a suggestion that falls into the "stitch in time saves nine" category. Let's assume that no matter what steps we take to dry the air, there still *may* be *some* moisture left in it.



Typical condenser-type dryer installation. Cooling coils in condenser reduces instrument air to desired dew point, removing moisture before it can reach instruments.

Assuming this, let's install all of our air piping so that there are no U-bends or low spots to act as condensate sumps. If we must have low spots, let's provide them with drains or traps.

Now to get into the subject of moisture removal. We can get rid of a lot of condensate by providing a trap at the bottom of the capacity tank. To still further increase the amount of moisture we can remove at this point, we can install cooling coils in or around the tank.

Ordinarily, a combination of these steps with the use of one of the previously described filter and dripwell units ahead of each instrument will do a satisfactory job of moisture removal.

However, under severe conditions, for example where the instruments or air supply lines will be subjected to freezing temperatures, you'll need a dryer.

The condenser-type dryer illustrated in a typical installation is the most economical. It uses cooling coils to lower the dew point of the air to within several degrees of the temperature of the cooling water or refrigerant in the coils.

When Do You Need a Dryer?

Chemical dryers are sometimes used to remove the last traces of moisture from air leaving a condenser-type dryer. They use chemical agents such as silica gel, calcium chloride, and lithium chloride. In these dryers, the drying agent must be periodically replaced or regenerated by steam or electric heating elements, a factor that you should consider before selecting a particular type.

Since dryers can be rather complicated and relatively costly to purchase and install, you should discuss your particular proposed installation with one or more dryer manufacturers before making a selection. They are experts in the field of air drying and can recommend the dryer that will do the best job for the least money.

Continued on page 16

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S - The MANUAL of test procedures
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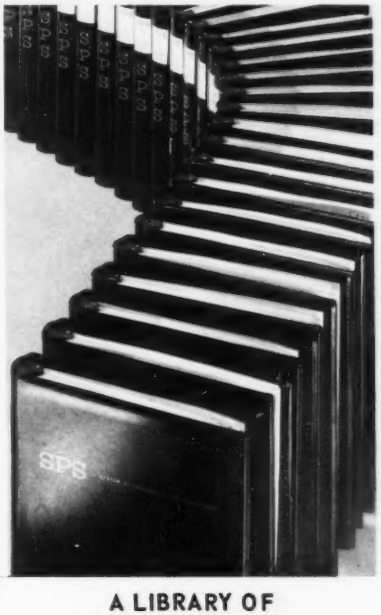

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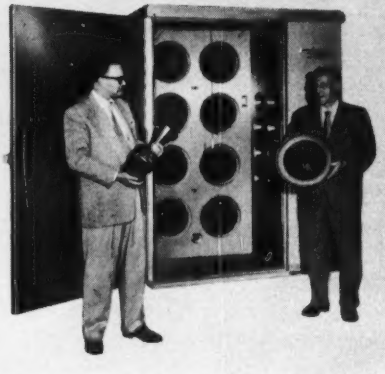

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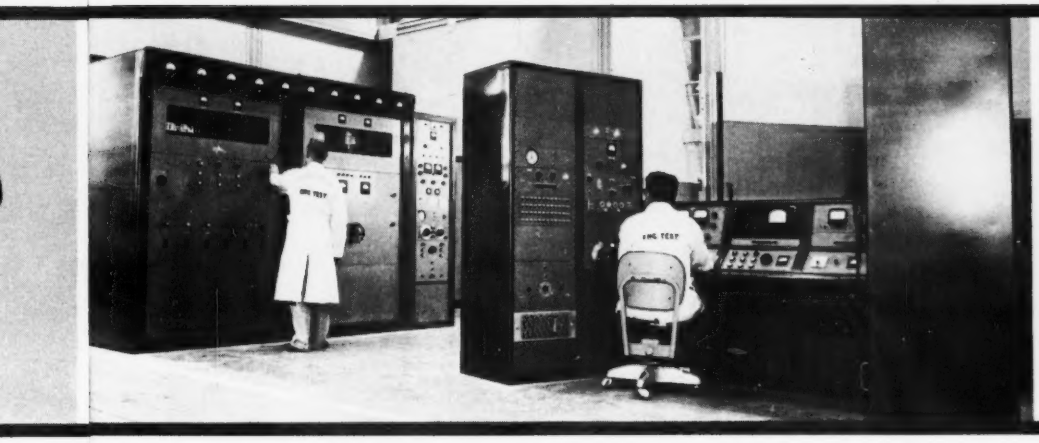

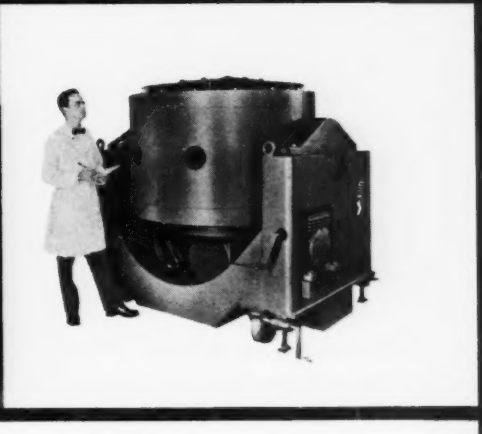

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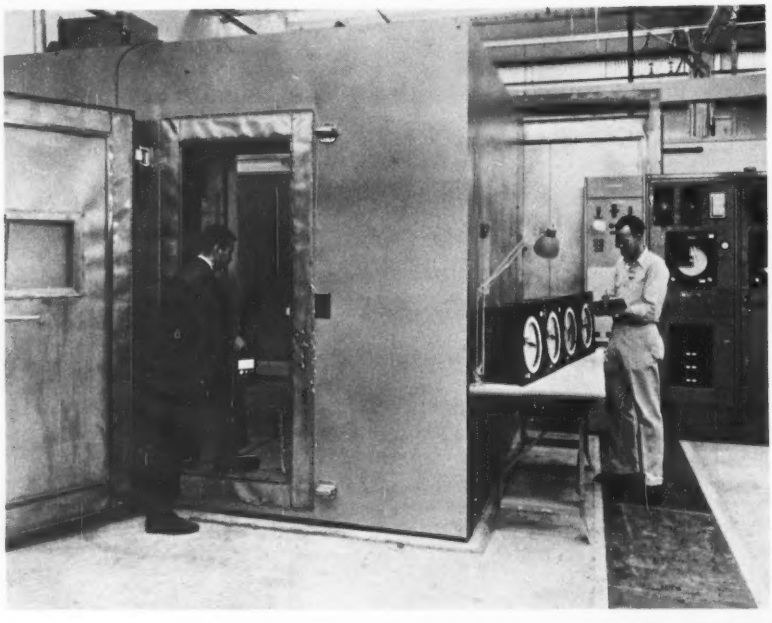

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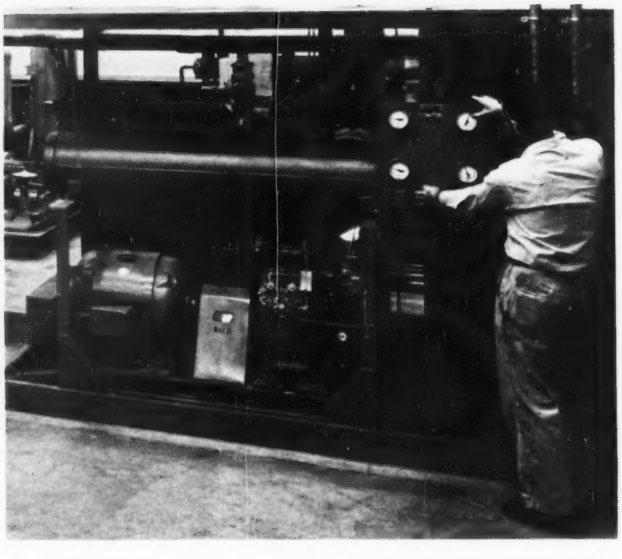

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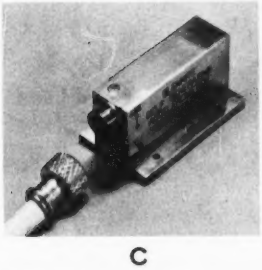
ENVIRONMENTAL TEST CHAMBERS

A

B



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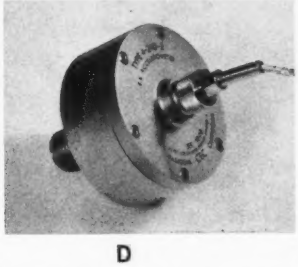

D

STATHAM strain-gage accelerometer (A), Edcliff potentiometric accelerometer (B), Gulton barium-titanate accelerometer (C), and CEC electrokinetic accelerometer (D).

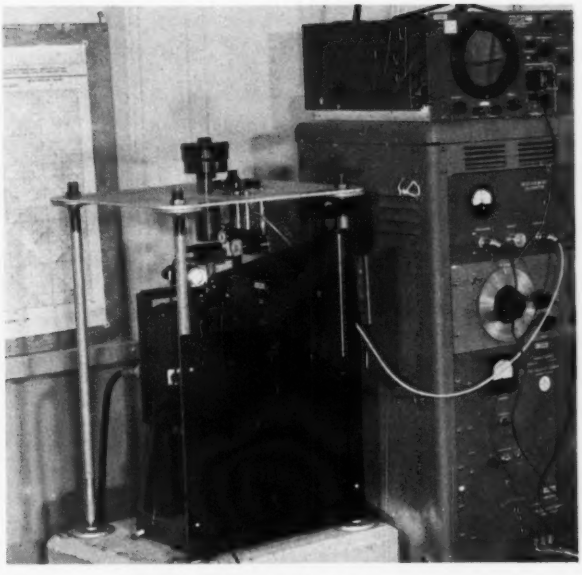

FIG. 1. PROJECTED-LIGHT displacement-measurement system.

ALVIN B. KAUFMAN
Litton Industries

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Accelerometer Calibration

LINEAR ACCELEROMETERS can be divided into two groups – absolute and vibratory. An absolute accelerometer indicates both steady-state and vibratory g forces; examples of these are strain-gage and potentiometric accelerometers. Vibratory accelerometers indicate changing forces only, but do not respond to steady-state forces. Examples of these are barium titanate and electrokinetic accelerometers.

Absolute accelerometers can be calibrated by use of the earth's gravitational force (0 to ±1g), or by a centrifuge. The technique is simple in both cases, but when using a centrifuge a warning note is in order. The potentiometric accelerometer employs a mass (or weight) which may move a considerable distance under various g loads. It is therefore essential to either physically or mathematically correct for this motion when the accelerometer is calibrated on a centrifuge because the seismic mass movement may appreciably change the centrifuge-accelerometer radius.

Vibratory Accelerometers

The vibratory accelerometer presents a different calibration problem where high accuracy, high frequency, or low g forces are involved.

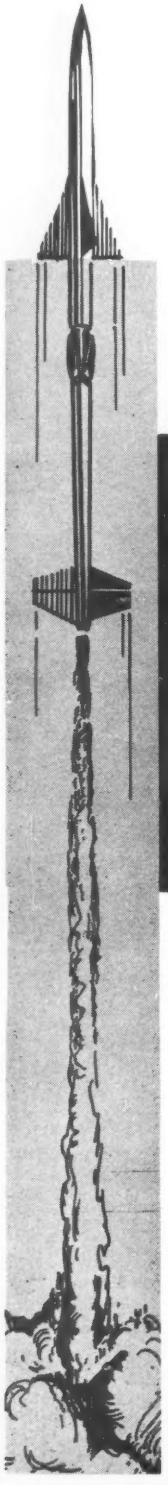
Since all commercial electrodynamic shakers have a 50:1 or smaller ratio between rated output force (in pounds) and weight of moving components (in pounds), no more than 50 g is directly available on any shaker[1]. Shakers of large force output are selected not for a huge g-force output but for the capability to shake a larger mass at accelerations under 50 g. Smaller shakers have less stray magnetic field to interfere with calibrations; also, sidesway is less serious in the smaller shakers[2] (the Calidyne A88 shaker with a force output of 100 pounds has been known to produce full-scale deflection of a nearby meter due to stray magnetic field flux). In addition to these reasons, a shaker is selected on the basis of other requirements.

Harmonic content in the driving power is undesirable. Also, low-frequency ripple noise and flutter are quite common and serious sources of error in commercial shakers. The g force of such low-frequency disturbances is exceedingly small, but the amplitude is large and serves to mask the amplitude measurement at the higher desired frequencies.

Continued to page 18

flight testing on the ground

Environmental and Performance Testing for Quality Control, Reliability, and Qualification of Electrical, Electronic and Electro-Mechanical Components, Sub-Assemblies and Assemblies



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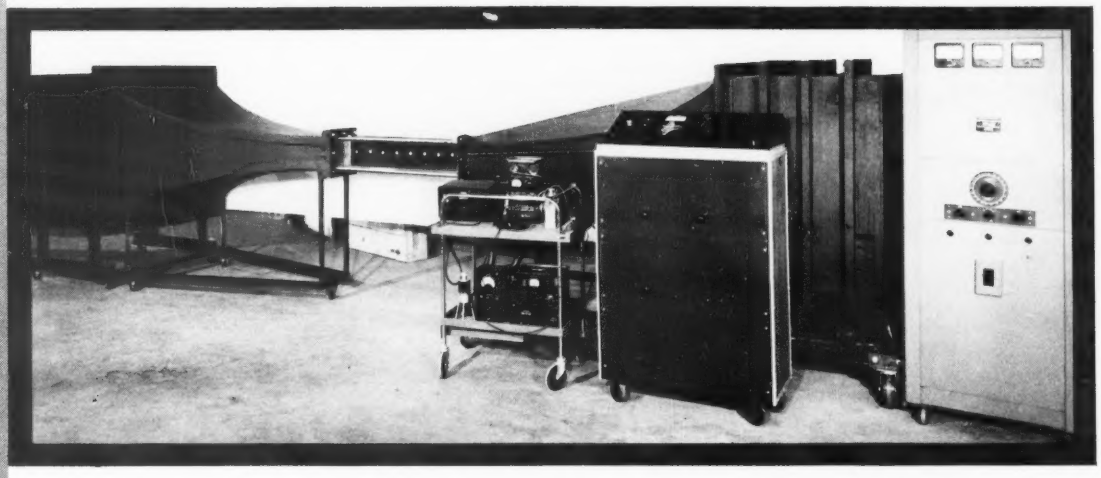

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Since your writing is judged by the same criteria as that of the professional writer, you must use the same methods to get comparable results. Some of these methods are really the writers' "tricks of the trade". One is the use of short sentences.

The short sentence is probably the greatest help to understandable writing. It permits spacing of ideas. Ideally, each sentence should be limited to one thought. Very often, however, simple sentences are incapable of communicating complete thoughts. Sentences become longer as modifying and qualifying words are introduced and as relationships between subject and object are developed.

As sentences become longer, relationships between words become less clear. Such sentences are harder to understand and may require rereading. They often lead to errors in grammar. Consequently, long sentences must be watched.

During recent years researchers have come up with a "readability formula" or criterion. The formula shows that when average length of sentences runs over 20 words, thoughts become difficult to understand.

Here is a standard in terms of words per average sentence:

Under 10 – Easy to read
15 – Fairly easy
20 – Standard
25 – Difficult
Over 30 – Very difficult

Here is how you can measure the readability of your writing. Pick several blocks of seven sentences at random throughout your manuscript. Average the sentence lengths of each block of seven; then average the average of each block.

Remember this: A sentence of over 25 words generally can be cut into two short ones. After several long sentences, insert a short one to act as a "rest" for the mind. Aim to get more sentences into the easily grasped 10– to 15–word length.

There's another reason why technical people in particular should write short sentences. In ordinary writing, shorter words can be sub-

Continued next page

stituted to help the reader understand. Generally, technical words cannot be simplified. Short sentences can compensate for this limitation.

Here's an example:

Technical sentence:
"Corrosion damage was not distributed uniformly on the tube surface but was concentrated at random locations."

Newspaper sentence:
"A 14–year–old boy was arrested last night while he was robbing a jewelry store."

Both sentences have 16 words. But the technical sentence has 92 letters in its 16 words, the newspaper sentence only 63 letters. Short, common words will help keep the letter-count down. Some technical people have trouble here.

Because of misplaced deference to convention, many empty, bookish, formalistic, and legalistic words and phrases creep into our speech and writing. Most of them can be called "nonworking" words. Cull them and substitute "action" words. Here are a few examples:

Avoid	Use instead
with respect to	for, about
effectuate	carry out
ascertain	find out, learn
for the purpose of	for
in the nature of	like
in view of the fact of	because, since
presently	now
along the lines of	like
subsequent to	for, after
avail yourself	use

Many technical people are troubled over paragraphing. What should a paragraph include? When do you begin a new paragraph? In modern usage, paragraphs are becoming shorter. In newspapers, for example, almost every sentence is a paragraph.

In technical reports, paragraphs should be well constructed. The first sentence of a good paragraph should be the topic sentence. It should tell the reader what's going to be said in the paragraph. It should also provide a transition (if such is needed) from the preceding paragraph. This topic sentence should be short and direct.

A good paragraph should also have a summarizing sentence which should warn the reader--"this is the end; prepare for another thought or another subject."

The length of a paragraph depends on two things: subject matter and consideration for the reader.

The rule of composition on paragraphing is clear. When the thought or subject promised in the topic sentence is exhausted, start a new paragraph. Consideration for the reader may modify this rule somewhat. Written with the reader in mind, paragraphs should do several things:

Give the reader visual evidence of a break in thought.
Provide just enough material on each thought or facet of a subject, not to tire his mind.
Provide a "hook" for the reader's attention.

Therefore, it is better to over-paragraph. The reader won't object.

There are three major pitfalls to paragraphing:

Lack of topic sentence.
Lack of unity.
Improper development of central thought.

To see if you have observed the rules of good paragraphing, check your paragraphs against these questions:

1. Is the topic sentence concise?
2. Does the paragraph need a transition sentence?
3. Does the paragraph contain more than one central thought? (Yes? Then split the paragraph.)
4. Can the paragraph be broken into two by regrouping information? (This is desirable and worth the effort.)
5. Does material in the paragraph cover what was promised in the topic sentence?
6. Is a summarizing sentence needed?

After you have written the first draft, edit it with a good dictionary at hand, and perhaps even a book on grammar to resolve doubtful construction.

Read your manuscript several times. First read over the entire draft to get the "feel" of it. Does it tell a story simply and concisely? Cut and shorten where possible.

Read it over a second time, looking for bad sentences, lack of topic sentences, and errors in grammar. If time permits, put the manuscript out of sight for a day or two. Then read it a third time before letting it out of your hands.

Paying attention to rules of composition and grammar is not enough. The professional writer soon learns many things that are not taught in college composition courses. You, as a report writer, should practice them too. For example, have confidence in your writing. You cannot do anything well unless you have confidence in your ability. Also, you must show interest in your writing. A good report is the result of a lot of hard work–and enthusiasm. But most of all, you've got to write if you want to be a good report writer. Writing is something that can be learned only through practice.

Institute of Environmental Sciences

East meets West

At the end of the 3rd Annual Meeting of the Institute of Environmental Engineers in Chicago on April 24th, an announcement was made by Roger J. Amorosi, retiring IEE President, that the Institute of Environmental Engineers and the Society of Environmental Engineers on the west coast had voted to merge. The new national organization will be known as the Institute of Environmental Sciences.

The IEE was incorporated in 1956 although it had existed prior to that time, 1954, as the science section of the Environmental Equipment Institute, an association of test chamber manufacturers. Mr. Amorosi was one of the founders of IEE, together with Harold C. Jones who is now the newly elected president of the Institute of Environmental Sciences.

The SEE was formed early in 1956 and was composed mainly of members from the Los Angeles area. William Vandal, who is now our new National Executive Vice President, was one of the founders of SEE.

The merger of the two societies is the result of negotiations which had been in progress over the past year. The decision of both groups to merge was based on the need for a stronger national organization. The purpose and principles of the society will reflect the similar aims of the two previous societies, namely, to advance the field of environmental engineering.

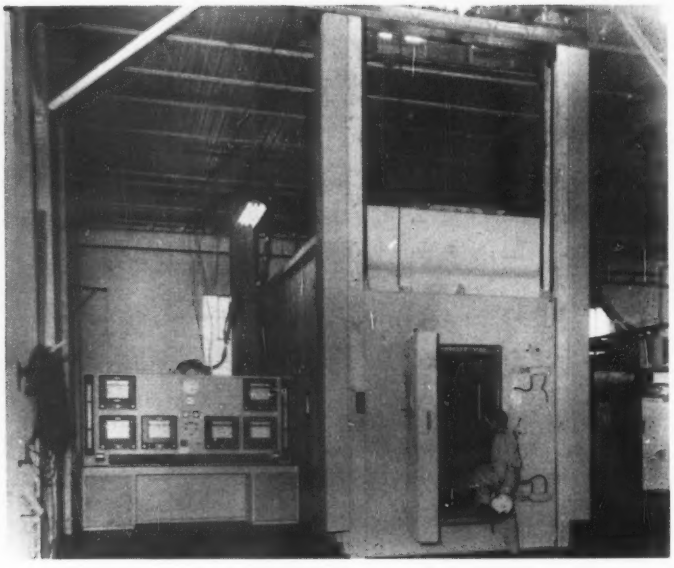
The organizational structure of the Institute is composed of the National Executive Committee and the Local Chapters. The Local Chapters elect their officers in accordance with the Chapter By-Laws which are approved by the National Executive Committee. Coordination of the functions of Local Chapters is handled through the National Directors from each Chapter and the Vice President in charge of Local Chapters. The National Executive Committee meetings are scheduled for Chicago on August 7, Los Angeles on December 4, and Washington, D. C. on February 12.

A brief description of the Executive Committee of the Institute of Environmental Sciences for the first year is as follows: President, Harold C. Jones, University of Maryland; Executive Vice President, William L. Vandal, Autonetics; Vice President, Fiscal Affairs, Arthur B. Billet, Vickers, Inc.; Vice President, Membership, Russell Lowe, Barry Controls; Vice President, Local Chapters, Leon Carver, High Accuracy Products; Vice President, Publications, Raymond G. Yaeger, Chrysler Missiles Division; Ex Officio Member, Roger Amorosi, Parameters, Inc.; and Henry Sander, Executive Secretary.

At a meeting of the new executive board, plans were formulated for the 1960 meeting of the Institute of Environmental Sciences in Los Angeles. Mr. W. L. Vandal, Executive Vice President, is the General Chairman. Mr. B. Forsher and Mr. J. Mason will be co-chairmen of Facilities, and Mr. N. Granick will be Chairman of the Technical Program. Mr. M. Christensen will be Chairman of Publicity for the event which is scheduled for April 6, 7, and 8 at the Biltmore Hotel in Los Angeles.

Information concerning the Institute of Environmental Sciences can be obtained from the National address which is Box 191 Mt. Prospect, Illinois, or from any of the Local Chapters.

For CONRAD Inc. Sales and Servi



1200 CU. FT. WALK-IN. This Conrad chamber is sectionalized to permit testing at high and low temperatures simultaneously. Range: —120°F. to +650°F., altitudes in excess of 125,000 ft. Capable of dissipating 40,000 watts at —100°F. Complete unit is prefabricated in three sections—main chamber, machinery, and instrument panel. Main chamber consists of two chambers with port in separating wall. In typical test, missile component is installed in port which is then sealed so high and low temperatures may be applied to different sections of component simultaneously.

MOBILE-TEMPERATURE UNIT. Conrad ingenuity designed this mobile unit to supply conditioned air. Range, —100°F. to +300°F. Supplies conditioned air, by self-contained pressure blower, for testing missile or other object in a separate chamber or temporary housing. Connects to facilities power source or portable power generator truck. Model illustrated is equipped with a 50 h.p. refrigeration system: other sizes available according to requirements. Iconel sheathed electric heaters handle rapid changes in high temperature demands.

CONRAD Inc.

HOLLAND, MICH.

Subsidiary, Crampton Mfg. Co.

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Next time there's a question about environmental test chambers, check with Conrad's West Coast representatives. Take advantage of their convenient location and their complete service on all types of chambers—walk-ins, portables, and standard models for altitude, humidity, temperature, and temperature-vibration testing. Widely experienced planning and engineering, installation and service by a factory-trained staff.

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Among the many firms in the West Coast area where Conrad environmental test chambers are installed are the following:

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Minneapolis Honeywell
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Sandia Corp.
Lockheed
Sperry Rand Corp.
Jet Propulsion Laboratories
Aero-Jet General Corp.
Boeing Aircraft

Right: Portable vibration-temperature chamber, with hydraulic hoist.

Below: Conrad's long experience assures accuracy in production techniques. These are Conrad FB-64 and FD-64 models, with 4' x 4' x 4' test space and temperature ranges from —100° to +300°.

THE SPECIAL PROBLEMS OF ENVIRONMENTAL SCIENCE

These are recognized at Litton Industries and rewarded with positions of scope and responsibility. Typical current openings, for which B.S. in E.E., M.E. or Physics is requisite, include:

GROUND SUPPORT ENGINEERING

5 years minimum experience in test base instrumentation, theory of range safety application and ground base instrumentation; in planning, using and applying static tests; with installation and uses of computer systems; direct experience in implementation and test of instrumentation.

INSTRUMENTATION

I. 8-10 years in technical capabilities; 2 years R&D in field liaison and associative problems; strong technical supervisory experience in the two areas of instrumentation and contract monitoring; ability to handle system engineering responsibilities.
II. 5 years in instrumentation and/or field experience, and a "feel" for data reduction equipment and its design.

GUIDANCE AND CONTROL SYSTEMS

I. 5+ years with antennas, a background in FM, some design experience.
II. 5+ years in ground radar; some design and detail experience desirable.
III. 5-10 years in field engineering, component and systems development, and field and flight evaluation.

Direct your inquiry to Mr. C. T. Petrie, Manager, Research and Engineering Staff, 336 North Footbill Road, Beverly Hills, California.

LITTON INDUSTRIES
Electronic Equipments Division

Continued from page 5

First, let's define "dew point." "Dew point," say the experts, "is the temperature at which condensation of water vapor in air takes place."

Any time there is a reduction in pressure, some cooling will result. In most installations, there are two locations where the temperature of the air is likely to drop to the dew point; (1) at the capacity tank, where warm air from the compressor cools to room temperature, and (2) at the instrument, where the air cools still further.

Knowing the average ambient conditions at these two locations, you can calculate the dew point necessary to prevent condensation. If this dew point is *below* that of the air entering the compressor you need a dryer.

Suppose we take a typical example to show what we mean:

Pressure of air leaving compressor	80 psig
Pressure of air at instrument	20 psig
Most humid condition at compressor intake	72% RH
Temperature at capacity tank	80° F
Temperature at instrument	30° F

Dew Point of Entering Air: By referring to the accompanying table, we find that at 72% RH and 80° F, the *dew point of the entering air is 70° F.*

Dew Point of Air in System: To arrive at this figure, we make use of the accompanying table and the following equation:

$$H_s = 0.62\left(\frac{P_s}{P - P_s}\right)$$

where

H_s = weight of water vapor in saturated air (lb. vapor/lb. dry air)

P_s = vapor pressure at saturation or 100% humidity (psi at temperature of air)

P = air pressure at point in question (psia)

(A) Dew Point at Tank

(1) P = 80 psig + 14.7 = 94.7 psia

(2) P_s = 0.50 psi (from table at 80° F and 100% RH)

(3) $H_s = 0.62\left(\frac{0.50}{94.7-0.50}\right) = 0.00328$

(4) From the table, the *dew point at the tank is 29° F.*

(B) Dew Point at Instrument

(1) P = 20 psig + 14.7 = 34.7 psia

(2) P_s = 0.082 (from table at 30° F and 100% RH)

(3) $H_s = 0.62\left(\frac{0.082}{34.7-0.082}\right) = 0.00147$

(4) From the table, the *dew point at the instrument is 12° F.*

This combination filter and dripwell has a ribbon-type filter cartridge that can remove foreign particles with dimensions as small as 40 microns.

Since the required dew point at both locations is below that of the entering air, we'll get condensation at both the capacity tank and the instrument if the air is not dried. Moreover, since the dew point at the instrument is lower than at the

Continued to page 24

—100°F TO +650°F DRY ICE TEMPERATURE CHAMBER

BEMCO

DF-100/650-1

Bemco Inc. has anticipated the need for higher performance in a one to two cubic foot BENCH TYPE— -100 F TO +650 F TEST CHAMBER. Includes all steel construction, stainless steel inside, cold rolled outside, 4" insulation, continuous air circulation, ±1.5 F control or better and many other features usually found only in large chambers.

Performance

A. Temperature Range	-100 F to +650 F
B. Control Tolerance	±1.5 F over entire range
C. Pull Down Time	+70 F to -85 F within 20 minutes +70 F to -100 F within 30 minutes
D. Pull Up Time	+70 F to +650 F within 60 minutes
E. Dry Ice Consumption	2.0 lb./hr. after stabilizing at control point. Dry ice compartment holds 50 lb. of dry ice.

Temperature is controlled thermostatically by electrical resistance heater elements in the blower duct. Dry ice consumption is kept to a minimum on low temperature runs by means of a manually adjusted by-pass damper.

A stainless steel dial thermometer calibrated in C. and F. is furnished for indication of temperature. This is a 1% instrument.

Toggle switches and pilot lights with engraved name plates are mounted on an instrument panel.

F. Optional Cooling System — Automatic liquid CO_2 thermostat controlled providing the larger test space.

Construction

10 in. wide x 17 in. long x 11 in. deep (1870 cu. in.). Note: By removal of dry ice baffle for high temperature testing, the full two cubic feet of test area may be utilized.

Approximate overall dimensions: 24 in. wide x 37 in. long x 20 in. high. Convenient, top loading compartment, sized to hold one full fifty pound block of dry ice.

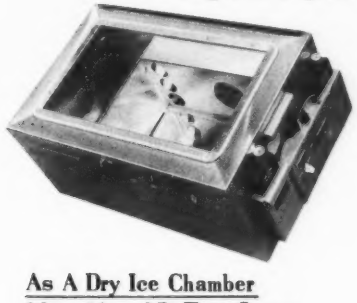
The inner liner is of type 304 bright finish stainless steel with all joints Heli-Arc welded and dye checked to insure a vapor tight liner.

The outside casing is sheet steel with four inches of fibreglass insulation.

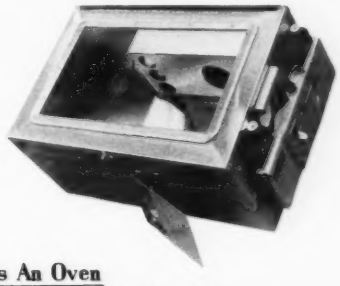
Constant air circulation is provided by means of a blower driven by an externally mounted motor.

Two 1 inch sleeves are provided in the side wall of the test compartment for test connections.

The exterior is finished in baked silver grey Hammertone enamel.



As A Dry Ice Chamber
10" x 11" x 17" Test Space



As An Oven
10" x 11" x 27" Test Space

Bemco also manufactures a complete line of environmental test equipment for all work with temperature, altitude, humidity, sand and dust, salt spray, fungus, sunshine, rain, explosion, and combined environments.

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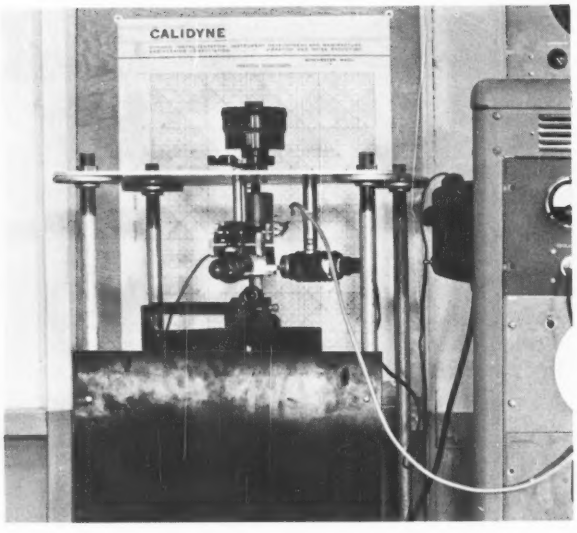

FIG. 2. MICROSCOPE DISPLACEMENT and sidesway monitor measurement system.

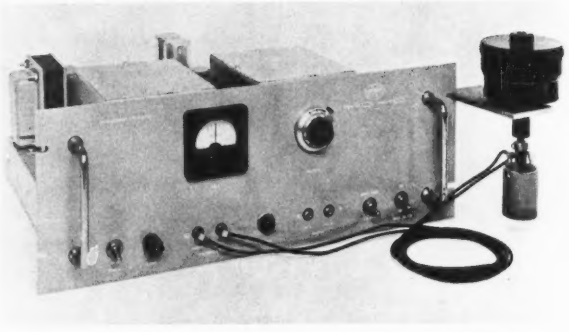

FIG. 3. A DEVELOPMENTAL non-contacting displacement calibrator with its measurement pickup. (Photo courtesy Arnoux Corp.)

Continued from page 9

Crystal shakers overcome some of these deficiencies but produce adequate g forces only at high frequencies and for small loads.

The three measurement items of chief concern in using a shaker are (1) true amplitude at the frequency for which g force is computed, (2) sidesway, and (3) frequency. The g force is a function of displacement and frequency. The equation $g = 0.0511Df^2$ (where D is double amplitude or DA in inches, f is frequency in cps, and g is peak value) indicates a requirement for accurate frequency measurement. Commercial digital frequency meters meet this calibration requirement.

Sidesway introduces a vector displacement not indicated by many displacement measurement systems. True displacement is undoubtedly the most complex measurement parameter, especially at high frequencies and at moderate g forces where displacement may be in microinches. Since all calibrations "boil down" to displacement measurement, displacement sensing accuracy is a good factor of merit.

Measurement of Displacement

The seven major methods used for the measurement of displacement or the dynamic calibration of accelerometers are as follows, (the specific techniques involved are discussed in the references noted):

1. Projected Light Source

This system employs a back-illuminated slit or hole (generally 0.001") mounted on the shaker work platform. A magnifier mounted on the shaker frame focuses a bright image of the slit on ground-glass-screen rule at suitable intervals. The transverse motion of the slit then appears as a broadening of the bright line against the ruled lines. Unfortunately, the magnifier magnifies the slit width as well as the amplitude of motion so that no better resolution than ±0.001" is obtainable (1% of typical 0.100" DA range), due in part to the granulation and halation inherent in the ground-glass screen. Such an error is equivalent to 2 g at 200 cps. Use in the frequency range of 10-100 cps is indicated. Sidesway cannot be monitored.

A typical commercial application (Fig. 1) is the Calidyne Optical System, Model 34.[2, 13]

2. Microscope

The microscope can handle smaller displacement (0.010" DA for 1% accuracy) because its measurement accuracy is ±0.0001". Thus, it can be used at higher frequencies at the same g force. This measurement method has an added advantage in that sidesway also is monitored and can be measured. Usable range is about 0.100" to 0.001".

Fig. 2 shows a typical microscope installation. A light source illuminates emery cloth; the reflection from a selected crystal is observed for displacement and table motion. Reference 2 specifies components.

3. Shaker Velocity-Pickup Coil

This system does not and cannot measure directly either displace-

Continued to page 20

L. C. MILLER COMPANY

Presents its

New

Lateral

Controlled

Motion

Vibration Tester

The LCM 100* is a new type of vibration exciter which features a horizontal, air supported, push-pull driven table. Although primarily designed for the *production testing* of components and small subassemblies, the unit's wide frequency range (5 to 15,000 CPS) and high force output will make it an ideal *research tool* for the product design engineer. The ruggedly built instrument is simple to operate, thus avoiding possible damage by inexperienced personnel.

AIR SUSPENSION

The shaker table is supported by *air bearings* which stiffly confine movement of the table in all directions but the axis of excitation. This new air suspension system eliminates troublesome springs and flexures; and reduces *cross talk*, a major problem with many shaker systems, to an exceptionally low value.

"Heavy" specimens are easily handled as the weight of the table and specimen is supported by air pressure normal to axis of excitation.

MORE EFFICIENT

Due to the low friction of the air bearings and the push-pull drive, the electrical efficiency of the shaker table is very high (2 watts per force pound as compared with 10 or more watts per force pound needed by conventional systems.) This enables efficient use of standard audio amplifiers which permits a substantial cost reduction over other vibration exciters using special high-power, limited-frequency amplifiers. Permanent magnets are used in the LCM 100 magnetic circuit to eliminate the need for separate field excitation and associated rectifying equipment. The impedance of the drive coils is designed to match the power amplifier over the entire audio range.

MORE ACCURATE

The LCM 100 is suitable for use with all forms of excitation including: discrete frequency, random noise, white noise, or complex wave form.

The design, including the use of a drive coil at each end of the table that cancels all structural resonances, results in a *low distortion* of the driving wave form. The table's first resonance is above 15 KC, and it's performance is monitored by a selected high frequency accelerometer which is built into the under side of the table.

**Manufactured under exclusive license from International Electronics Research Corporation, Burburbank, California.*

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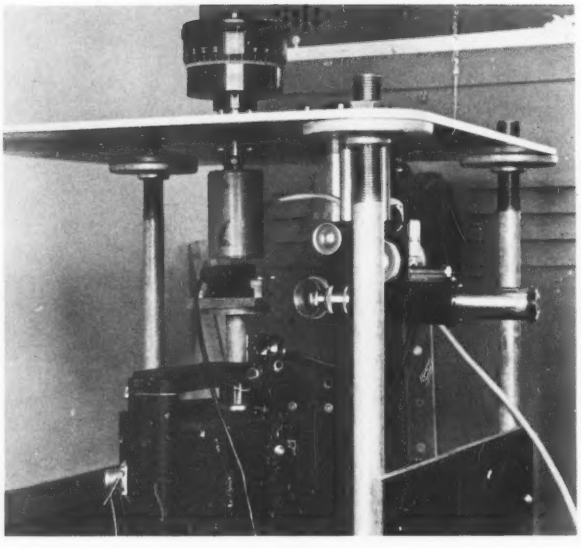


FIG. 4. NON-CONTACTING mutual-inductance displacement calibrator pickup with its micrometer head is shown at top. A Gulton A500 Series accelerometer and a microscope system are also visible.

FIG. 5. GULTON AT-16 interferometer with AT-20A crystal shaker.

Continued from page 18

ment or acceleration because both are maximum when velocity is zero. This system is full of traps, pitfalls, and involvements, but has one advantage in that the effect of low-frequency noise is minimized. The velocity signal must be integrated to indicate displacement, and the resultant signal is accurate only with sinusoidal signals of low harmonic content. Sidesway is not measured so the signal does not indicate true displacement if sidesway is present. Specific parameters are presented in References 1, 2, 3, 4 and 13.

4. Calibrated Accelerometers

Three light-weight accelerometers mounted on the shake table can measure acceleration along three axes. However, they require several primary standards to calibrate them initially throughout the frequency range used. They can be calibrated initially with the microscope at low frequencies, or with a displacement calibrator at high frequencies (see next item, 5). Where barium titanate accelerometers are used, the output signal directly indicates vibratory g force independent of frequency. For this reason the system can be calibrated at low frequency via the microscopic technique, and used up to approximately 10-20% of the accelerometer f_n, regardless of critical damping (within 0.4 to 0.9), and without a high-frequency calibration.

This system, allowing direct readout of g force is excellent for production calibration of accelerometers. Low-frequency table noise is not a measurement problem as with the optical system.[5]

5. Displacement Calibrator

The use of either a non-contacting mutual inductance, a capacitance pickup, or a light-beam follower allows direct measurement of table motion from static through a high-frequency dynamic range. Low-frequency table noise, 120-cps power-supply table motion (or ambient light fluctuations), and linearity present problems. Discounting these factors, accuracy can be as high as one microinch, but is usually 5 to 100 microinches. The mutual inductance and capacity units employ a precision micrometer for calibration of the pickup with static deflections; therefore, accuracy of the system for quasi-static through the full range of dynamic frequencies used must be evaluated.

Fig. 3 shows a development mutual-inductance displacement calibrator; Fig. 4 shows the pickup installed on a shaker. The unit shown does not rely on absolute linearity; an oscilloscope is used as a transfer indicator. The dynamic table motion pattern is matched to the previous scope amplitudes obtained by micrometer adjustment. Typical circuits and equipment can be reviewed by referral to References 1, 6, 7, 8 and 9.

Continued to page 25

NEW products

NEW PRODUCTS RELEASE

Conrad, Inc. has developed a brand new idea which will fulfill the test technicians requirements for a portable self-contained environmental test chamber of minimum floor space. This unit is identified as Conrad Temp. Rac 19. The unit fits into a standard 19" wide relay rack. The chamber is 1½ cubit feet. The unit is completely packaged as an assembly to slide into a customer's standard relay rack or can be furnished with the relay rack housing enclosure.

The unit is supplied with indicating controller. Forced air circulator, electric heating, and direct refrigeration with patented Conrad Cascade F-13 - F-33 system.

For further information contact:

Conrad, Inc.
Conrad Square
Holland, Michigan

MB INTRODUCES NEW VIBRATION EXCITER

A new vibration exciter for envimental testing has been announced by MB Manufacturing Company.

Designated Model C125, the exciter can be used for conventional sine wave testing, or for the newer random or complex motion techniques. And, according to MB, it incorporates a new design concept to provide in the same size unit up to 40 per cent more force output for more efficient utilization of power amplifier output.

The new exciter has a vector force output of 10,000 lb, and a frequency range of 5 to 2,500 cps. Weight of the moving element is approximately 100 lb; its axial resonance is well above 2,500 cps. The exciter is liquid cooled for environmental test chamber applications in ambient temperatures from −100 °F to 300 °F, and at altitudes up to 250,000 ft.

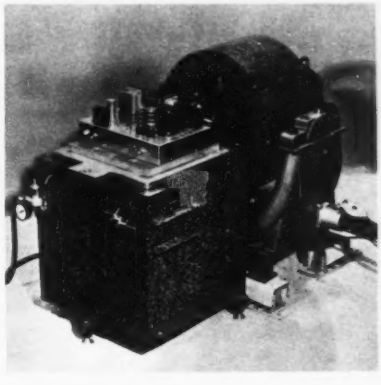
For further information, contact:

MB Manufacturing Company
Box 1825
New Haven 8, Connecticut

NEW VIBRA-PLANE

The development and testing of the production model of our new horizontal vibrating "slippery" table (we call it the Vibra-Plane) has been completed.

Overload tests with the new *variable pressure-air bearing* have made it possible to accept heavy loads for testing on the Vibra-Plane as well as more conventional loads.



High frequency vibration tests have proven that integrally casting the drive rods with the moving platform, to increase rigidity, is definitely worthwhile. In addition, casting two drive rods, one on each end of the platform makes it easy to adapt to different shaker heads. The cohesive action of the oil bearing, as expected, greatly assists in eliminating rotational inputs and increases unidirectional vibration stability. Provisions (not shown in photo) have been made for collecting excess oil in the Vibra-Plane base.

The moving platform size has been established at 20 in. x 20 in., the weight at 20 lbs. (If desired a "bolt down" hole pattern to customer's specs can be provided at an additional cost.)

For further information contact:

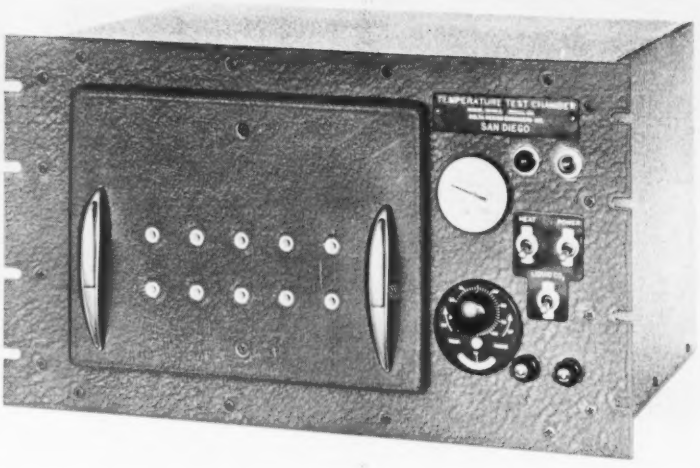
Allied Research Associates, Inc.
42 Leon Street
Boston 15, Massachusetts

Continued next page

Moving to a new plant facility last week has more than doubled the engineering, manufacturing and office space of Missimers Incorporated.

Located at 3737 San Fernando Road, Glendale 4, California, the new plant houses the manufacturing of Missimers Environmental Test Chambers, Technical Refrigeration Equipment and sales distribution offices of Spraying Systems, Inc., according to Dale J. Missimers, Jr., Vice President of the company.

One innovation of the new building is in the location of all utilities for availability to every square foot of the plant. Missimers pointed out that in addition to allowing for the most efficient production flow, this availability of air, water and power to any point makes the entire plant a test floor. Long-term performance tests can be run -- even during manufacture -- at any spot in the manufacturing area.



Rack Mounted Temperature Chamber

A compact, time saving, rack mounted Temperature Test Chamber having a range of −100 °F to +500 °F is now available from Delta Design Engineers, Inc. This convenient Model 6545R has a test volume of 10" x 7" x 7", while occupying only 10½" in height in a standard 19" rack. Model 6545R is especially useful where several chambers are needed or where bench space is limited.

A sensitive, direct reading thermostat automatically controls temperature within ± 2 °F at any point in the range. Low temperatures are attained very rapidly by injection of liquid CO_2 through a solenoid operated valve. A built-in heating element provides high temperatures.

For further information on this and other chambers, write Delta Design Engineers, Inc., 7460 Girard Avenue, La Jolla, California.

TECHNICAL INFORMATION

"VIBRATION TESTING PRIMER"

"Vibration Testing Primer," first of a series of "Vibration Testing Topics," which simultaneously will provide a basic manual on the art and science of dynamic testing, will be available to industry and military services without charge. The company issuing the primer is newly formed and engaged in providing professional engineering services on an advisory, training or task basis covering the full scope of vibration problems.

Source: Unholtz-Dickie Corp.
Hamden, Connecticut

"VIBRATION MANUAL"

The "Vibration Manual for Engineers," 2nd edition, a Navy Publication containing formulas useful to design engineers in minimizing mechanical vibration difficulties, is available through the Office of Technical Services, U. S. Department of Commerce. The manual was prepared by the Structural Division of the Navy's David Taylor Model Basin. It is a revision of an earlier manual with the same title issued in 1944. Most formulas conform with a notation based on the inch-pound-second system of units. They are presented in case form and are illustrated and explained. The manual contains 32 pages and price is $1.00.

Source: U. S. Department of Commerce
Washington 25, D. C.

TECHNICAL DATA AND CONVERSION CHARTS

Conrad, Inc., Environmental Test Chamber Manufacture, offers free of charge a series of conversion charts and technical data covering altitude pressure and temperature from −5000 feet altitude to 1,800,000 feet altitude in accordance with ARDC model atmosphere. Also included is centigrade to fahrenheit conversion factors from absolute 0 to 1000 degrees and several conversion factors for materials, heat, velocity, and vacuum. Two other charts list dry bulb and temperature differential for relative humidity.

Source: Conrad, Inc.
Conrad Square
Holland, Michigan

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Altitudes to 200,000 ft., temperatures from –100° F to +350° F, in only 4 square feet of floor space. Now, any company can own a combined altitude and temperature test chamber . . . without sacrificing much valuable floor space. And the investment, too, is reasonable.

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Names and Faces

MB PRESIDENT ANNOUNCES NEW FACILITIES

NEW HAVEN, Conn. -- The formation of Propulsion Test Facilities, Inc., affiliate of MB Manufacturing Company, a division of Textron Inc., was announced here today by George Mettler (left), MB president. Mr. Mettler also will serve as president of the new company. Operating responsibilities will be handled by Norman G. Froomkin (right), vice president and general manager.

Believed to be the first organization of its kind, Propulsion Test Facilities, Inc., offers complete "packaged" environmental test facilities to meet "the critical national need for improved aircraft and missile reliability," according to Mr. Mettler.

Address: 781 Whalley Ave.
New Haven 8, Conn.

LING BEGINS CONSTRUCTION OF NEW PLANT

A. A. Ward, president of Altec; James J. Ling, chairman of Ling, and Cameron G. Pierce, president of Ling, prepare to break ground for new Ling Electronics, Inc. manufacturing facility at the Anaheim plant of the Altec Companies, newly acquired Ling subsidiary.

The new manufacturing plant of 45,000 square feet, costing in excess of $500,000, will substantially increase production facilities. This new construction is part of a master plan to establish the most efficient use of facilities in the integrated Ling-Altec operation.

IAN WILLIAMSON JOINS LING AS MANAGER OF FIELD SERVICE ENGINEERING

Ian Williamson has joined Ling Electronics, Inc., as manager of field service engineering effective January 26th. Announcement of the appointment was made by Ling President Cameron G. Pierce.

"Mr. Williamson's thorough knowledge and working experience in vibration testing, including acoustic methods, particularly equips him for this important post," said Pierce.

For the past thirteen years, Williamson has been with Douglas Aircraft of Santa Monica, (Calif.) where he was in charge of the acoustics and vibration group of the testing division, aircraft and missiles.

Continued from page 16

tank, we'll get additional condensation at the instrument, even though much of the moisture condenses in the tank.

In this case, we should have a dryer capable of reducing the dew point of the instrument air to 12° F. The logical location for the dryer is downstream from the capacity tank, as much of the moisture will condense in the tank.

When making a similar calculation to determine whether or not you will need a dryer, you would, of course, select the most humid condition you'd be likely to have at the compressor intake and the lowest temperatures that you'd likely encounter at the instruments and the capacity tank.

This, then, is the story on instrument air and how to keep it clean and dry. You wouldn't buy a new car, fill the tank with gasoline containing grit and water, and expect it to give you the excellent service for which it was designed. Pneumatic instruments and control systems are designed to far more rigid specifications than even the most expensive car. Give them the same consideration you'd give your car and you'll be happy with the job they'll do for you.

Continued from page 20

6. Interferometer

The interferometer (Fig. 5) is useful in the range between 4 and 200 microinches and indicates displacement accurately at 4 microinch intervals, depending on light source. Accuracy is approximately 6%. In general the interferometer method of displacement calibration is considered applicable only for precise laboratory work. However, the advent of a commercial unit has made feasible production-type calibrating. The difficulties in technique involved, and the usable range, indicate it is most applicable in conjunction with crystal shakers. Electro-dynamic shaker-table noise cannot be tolerated. Sidesway is not permissible with the crystal or electro-dynamic shaker.

This method of displacement measurement is best suited for high-frequency, high-g calibrations [10, 11, 12].

7. Reciprocity

Displacement is not measured or required for this indirect method of calibration, which depends on (1) the existence of coupling between seismic mass and accelerometer case and (2) exact knowledge of the coupling. Thus, the method might be used on a compression-type crystal accelerometer but would fail completely when used on some accelerometers where the seismic mass is mounted at its motional node.

Strain-gage and potentiometric accelerometers cannot be calibrated by this method. The seismic mass must be capable of electrical excitation such that case movement occurs. Case coupling coefficients and other factors indicate that this method of calibration is not, in general, satisfactory [14].

Conclusion

The data presented indicate the major systems and parameters for accelerometer calibration. To a great extent the selection of the displacement or calibration measurement system depends on the limitations in calibration accuracy and the frequency spectrum required.

If the accelerometer is a first-order system with its damping known, its frequency response [15, 16] can be predicated on the f_n of the accelerometer, and low-frequency calibration measurements suffice. Unfortunately, most accelerometers are not first-order systems; nevertheless, flat frequency response to 10-20% of the f_n (where h = 0.4 to 0.9) can be assumed. Use of higher frequencies makes calibration necessary.

Resonant beams require one of the measurement systems discussed. Ballistic pendulum[17] and shock devices were not considered in this discussion of vibratory calibration methods.

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16. Alvin B. Kaufman, "Measurement of Natural Frequency," *Instruments & Automation*, Dec., 1957.

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I.E.S. news letter

JOURNAL EDITOR RESIGNS

We regret to inform members of the Institute of the Environmental Sciences and readers that Frank Kramer has resigned as Editor of the Journal of Environmental Engineering.

Increasing duties at Space Technology Laboratories and the necessity for frequent trips to Florida, related to missile programs, would prove a serious handicap. Therefore Frank felt the best interests of the Journal would be served if he relinquished the Editorship.

Frank is to be congratulated for formulating and guiding the first issues of the Journal in such an excellent manner.

Charles W. Danielson, of Litton Industries, who joined the Journal in March as Technical Editor has assumed the duties of Editor and will guide future publications in cooperation with R. G. Yaeger, IES Publications Vice President.

LOS ANGELES CHAPTER
June Meeting

Members of the Los Angeles Chapter met June 1st at the Rodger Young Auditorium for the regular bi-monthly meeting.

Following a social hour and dinner, Jerry Bakalish, Chairman of the L. A. Chapter, started the meeting by introducing new Board Members Bill Grumet, Chairman of the Standards and Specifications Committee, and Bruno Forsher, Member-at-Large. Bill and Bruno were previously Board Members of the L. A. Chapter of IEE.

Brief reports concerning chapter activities were given by George Clark, Treasurer, C. Danielson, Managing Editor of the Journal and Jim Jordon, Membership Chairman. Bill Grumet detailed the current activities of the IES' Standards and Specifications Committee. He also mentioned a general meeting, open to all members, will be held on Wednesday, June 24th, at 7:30 P.M. at the Western Gear Lynwood Plant, 2600 East Imperial Highway, Engineering Building. The main purpose of this meeting will be to select participating members for Ray Tomrin's specification files group and to help formally establish 3 additional subcommittees to handle the following specific matters:

(1) Establishment of a general procedure covering acceleration testing.

(2) Establishment of general procedures covering shock testing to standard military requirements.

(3) A general procedure covering acoustical testing.

Bill Vandal, IES National Executive Vice President, informed the members of proceedings at the IEE Convention in Chicago and of the meetings pertaining to the merger of the two Societies.

Following a brief adjournment, the speaker for the evening, Mr. Chadwick of the Chadwick-Helmuth Company, was introduced. His talk and demonstration presented means of taking slow-motion photography of vibration testing using conventional strobe lights and a moving-picture camera slaved to the vibration exciter. High-speed motion pictures and slides were used in the demonstration.

NATIONAL ELECTRONICS CONFERENCE SETS OCTOBER 12–14 FOR 1959 SESSIONS

The 15th National Electronics Conference will meet October 12-14, 1959 at the Hotel Sherman, Chicago, according to Virgil H. Disney, president. The 1959 NEC will hold sessions in adaptive servomechanisms, antennas and propagation, audio, circuit theory, communications systems, computers, information theory, instrumentation and telemetry, masers, microminiaturization, microwaves, millimeter waves, parametric amplifiers, plasma research, radar and radio navigation, servomechanisms, signal matched filters, solid-state circuits and devices, space electronics, communication and navigation, television, transistors, and value engineering.

COMING EVENTS

June 16–19: National Summer Meeting, Institute of the Aeronautical Sciences, Ambassador Hotel, Los Angeles.

June 29–July 1: Third National Convention on Military Electronics, Sherator-Park Hotel, Washington, D. C. Sponsor: Institute of Radio Engineers Professional Group on Military Electronics.

July 16–17: Third biennial Joint Meeting, Radio Technical Commission for Aeronautics and Los Angeles Section of the Institute of Radio Engineers, Ambassador Hotel, Los Angeles.

August 4–5: Second Annual Western Regional Meeting, American Astronautical Society, Ambassador Hotel, Los Angeles.

August 18–21: Western Electronic Show and convention, San Francisco. Write WESCON, 1435 S. La Cienega Blvd., Los Angeles.

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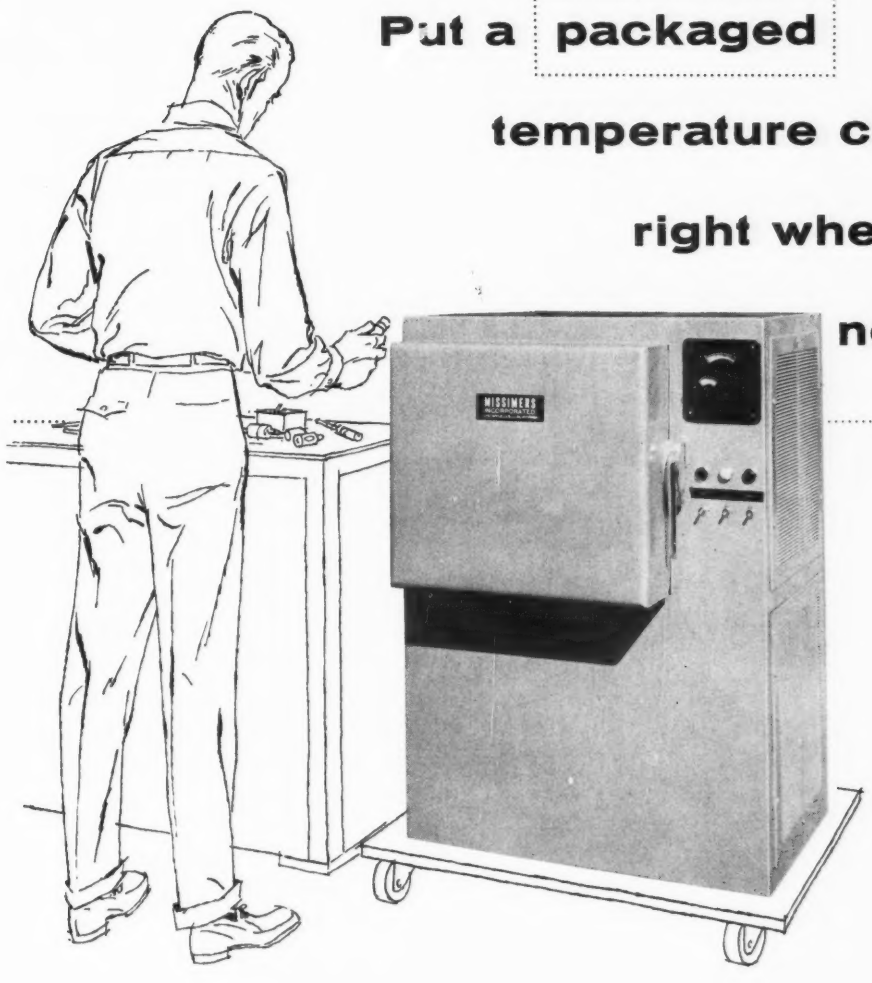


THIS ECONOMICAL MISSIMERS CHAMBER MEETS MIL-SPEC ACCURACIES WITH PLUG-IN SIMPLICITY

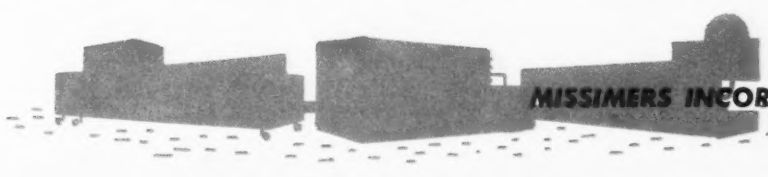
Quickly set up almost anywhere, this new unit is designed to fill the need in many testing laboratories and company facilities for an accurate, yet economical temperature chamber. It can handle overflow work from larger chambers, run qualification and reliability tests on small products or components, and is ideal for production processing and temperature stabilization work.

A hermetically-sealed cascade refrigeration system provides temperatures to −100°F, and a special heating unit to 350°F. Temperatures are controlled to ±3°F over the full range.

The one cubic foot working space has a full opening door. Forced air circulation provides uniform temperatures within the chamber.

As a standard model, this chamber is priced to be practical for almost anyone... will test to Mil-Specs... and is guaranteed for a full year.

Write for specifications and prices on Model FT1-100x350, or for information on any of Missimers full line of environmental chambers.



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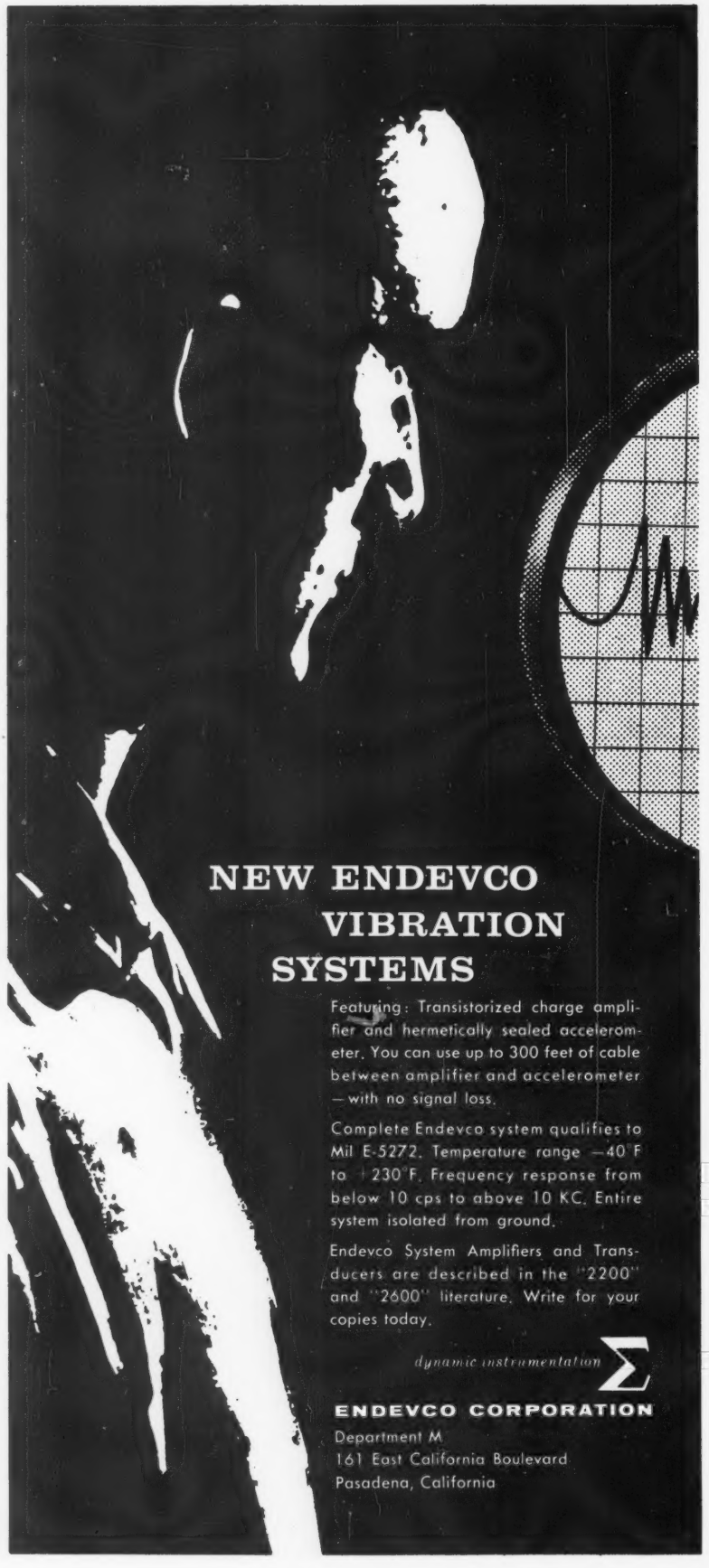
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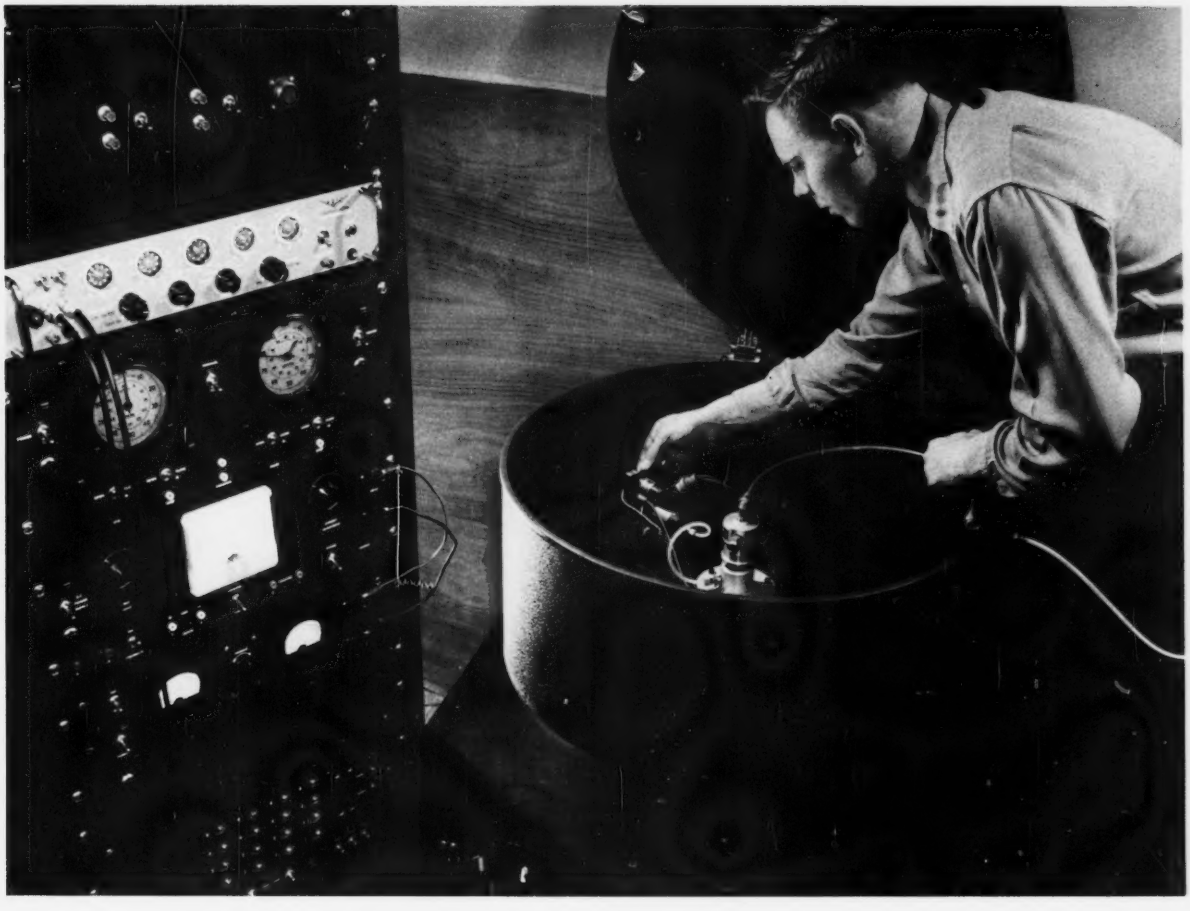
Membership in SEE

Several classes of membership will be provided in the Institute of Environmental Sciences which parallel those of other societies, namely: Fellow, Honorary Fellow, Member, Associate Member, Student, Government Member, and Company Member. Requirements for the individual classes of membership are presently being established and will be available upon application for membership. All present members of SEE and IEE will automatically be eligible for the member classification without further qualification. Fellows and Members are eligible to vote and hold office. Associate Members may vote but cannot hold office. Student, Government and Honorary Members do not vote or hold office.

APPLICATIONS

For further information regarding membership write to The Journal of Environmental Engineering, 11916 West Washington Blvd., Los Angeles 66, California. Attention Russell Lowe, Vice Pres., Publications.



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Genisco Model A903 features simplified operating procedures; rugged construction...for fast, accurate testing to MIL-E-5272A, Procedure II

Although the A903 is a simple, low cost centrifuge, it has many features found in more sophisticated machines, *plus* unique features which particularly suit it for production-line testing and evaluation programs.

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SPEEDS TESTING—24" diameter mounting-table will accommodate several test objects. Arranged symmetrically, they can be subjected to acceleration forces simultaneously.

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G-Range: 1 to 1,000 g's in five standard ranges, infinitely variable

G-Pound Capacity: 2,500 g pounds, maximum

Constancy of Rotation:

Wow: 0.5%, maximum

Drift: 0.2% of rate per minute, maximum

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Tachometer: ±1¼%

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Vibration Isolation: 0.1 g in any plane, at any speed

Test Object Dimensions: 8" high (24" diameter circular platform)

Slip Rings: 8 standard, 10 amp. maximum

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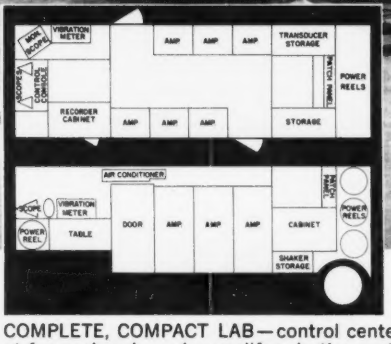

COMPLETE, COMPACT LAB—control center at forward end . . . six amplifers in the center and patching panels with power reels at the rear.

Douglas gives the entire DC-8 a vibration "shake-down" with this new mobile test laboratory

A complete Ling vibration testing laboratory on wheels allows Douglas Aircraft to simulate actual flight vibrations without ever leaving the ground!

This new Ling unit is a self-contained laboratory, with up to 12 shakers integrated into a single system.

For the first time it provides an efficient means of testing the entire aircraft, missile or other large component while fully assembled. Structural vibrational characteristics of the complete airframe can be determined under various dynamic loadings, and the chances of test inaccuracies through mismatched or temporary connections are reduced. Further, important time and money savings are realized with this on-the-job test lab.

A new bulletin giving full information and specification data on this new Ling mobile unit will soon be available. Write for your copy now!

MASTER CONTROL CONSOLE features front panel reading and easily accessible control of all basic system functions.

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